

RADIALLY SYMMETRICAL OPTOELECTRIC MODULE

Invented by

**Bradley S. Levin**

a resident of  
628 Forest Avenue, Apt. C  
Palo Alto, California 94301

**Oliver W. Northrup**

a resident of  
1336 Gilmore Street  
Mountain View, California 94040

and

**Joseph John Vandenberg**

a resident of  
415 North Lark Ellen Avenue  
West Covina, California 91791

all citizens of  
the United States

1                   RADIALLY SYMMETRICAL OPTOELECTRIC MODULE

2  
3                   CROSS REFERENCE TO RELATED APPLICATION

4  
5           This application claims the benefit of U.S. Provisional  
6 Application No. 60/274,999, filed 12 March 2001.

7  
8  
9                   FIELD OF THE INVENTION

10  
11           This invention relates to optical-to-electrical and  
12 electrical-to-optical modules.

13  
14           More particularly, the present invention relates to  
15 optical-to-electrical and electrical-to-optical modules that  
16 are radially symmetrical about a longitudinal axis.

17  
18           And more specifically the present invention pertains to  
19 optical-to-electrical and electrical-to-optical modules that  
20 incorporate a lens system, along with the radially  
21 symmetrical features that compensate for temperature  
22 changes.

1 BACKGROUND OF THE INVENTION

2  
3 In optical-to-electrical and electrical-to-optical  
4 (hereinafter "optoelectric") modules used in the various  
5 communications fields, one of the problems that must be  
6 solved is the efficient transmission of light between a  
7 light generating device and an optical fiber or,  
8 alternatively, the transmission of light from the optical  
9 fiber to a light receiving device without being affected by  
10 temperature changes and the like. Here, it will be  
11 understood by those skilled in the art that the term "light"  
12 is a generic term that includes any electromagnetic  
13 radiation that can be modulated and transmitted by optical  
14 fibers or other optical transmission lines.

15  
16 Here it will be understood that the optoelectric  
17 modules are used to communicate between an optical fiber and  
18 an optoelectric device, such as a light source (e.g. a  
19 laser, light emitting diode, etc.) generally referred to as  
20 a transmission module, or between an optical fiber and a  
21 light receiving device (e.g. a photodiode, PIN diode, PN  
22 diode, etc.) generally referred to as a receiving module.  
23 In this disclosure both modules are referred to generically  
24 as optoelectric modules.

1 Generally, one of the problems with optoelectric  
2 modules is the amount of time and effort required in the  
3 fabrication and assembly. Another problem that arises is  
4 that much of the time and effort in assembly and mounting is  
5 applied in alignment of the various components so that light  
6 generated by, for example a laser, reaches the core of an  
7 optical fiber and light emanating from an optical fiber must  
8 be directed onto a photo diode or the like. After  
9 substantial time is expended in the original alignment  
10 procedures, temperature changes and the like during  
11 operation can substantially change the alignment and cause  
12 substantial changes in the amount of light being usefully  
13 applied. These changes can substantially affect the  
14 continued operation of the modules.

15  
16 It would be highly advantageous, therefore, to remedy  
17 the foregoing and other deficiencies inherent in the prior  
18 art.

19  
20 Accordingly, it is an object the present invention to  
21 provide new and improved radially symmetrical optoelectric  
22 modules.

23  
24 Another object of the present invention is to provide  
25 new and improved radially symmetrical optoelectric modules

1 that further incorporate a novel lens systems so that  
2 expansion and/or contraction during changes in temperature  
3 does not affect alignment.

4

5 Another object of the present invention is to provide  
6 new and improved radially symmetrical optoelectric modules  
7 that are easily aligned and assembled.

8

9 Another object of the present invention is to provide  
10 new and improved radially symmetrical optoelectric modules  
11 that remain aligned during changes in operating temperature.

12

13

14 And another object of the present invention is to  
15 provide new and improved radially symmetrical optoelectric  
16 modules that improve the efficiency of optical systems.

17

18 Still another object of the present invention is to  
19 provide new and improved radially symmetrical optoelectric  
20 modules that allow the use of a variety of components and  
21 component materials.

1 SUMMARY OF THE INVENTION

2

3 Briefly, to achieve the desired objects of the present  
4 invention in accordance with a preferred embodiment thereof,  
5 provided is a radially symmetrical optoelectric module  
6 including a symmetrical ferrule defining an axial opening  
7 extending along an optical axis and having first and second  
8 ends positioned along the optical axis. The ferrule is  
9 formed radially symmetrical about the optical axis with a  
10 lens assembly engaged in the ferrule along the optical axis.  
11 A first end of the ferrule is formed to receive an optical  
12 fiber such that an end of the optical fiber is positioned  
13 along the optical axis and adjacent the lens assembly and  
14 light passing through the optical fiber is acted upon by the  
15 lens assembly and an optoelectric device is affixed to the  
16 second end of the ferrule so that light traveling along the  
17 optical axis appears at the optoelectric device.

18

19 In a preferred embodiment, the radially symmetrical  
20 optoelectric module includes a receptacle assembly with a  
21 symmetrical ferrule and a first lens. The ferrule defines  
22 an axial opening extending along an optical axis and has  
23 first and second ends positioned along the optical axis.  
24 The ferrule is formed radially symmetrical about the optical  
25 axis and the first lens is engaged in the ferrule along the  
26 optical axis. The first end of the ferrule is formed to

1 receive an optical fiber such that an end of the optical  
2 fiber is positioned along the optical axis and adjacent the  
3 first lens with light passing through the optical fiber  
4 being acted upon by the first lens. An optoelectric package  
5 includes an optoelectric device and a second lens positioned  
6 adjacent the optoelectric device, the second lens is mounted  
7 along the optical axis by the optoelectric package. The  
8 optoelectric package is affixed to the second end of the  
9 ferrule so that light traveling along the optical axis  
10 appears at the optoelectric device and passes through the  
11 second lens. Because of the "two lens system" axial spacing  
12 of the structural components is not critical and because of  
13 the combination of radial symmetry and the two lenses, the  
14 module expands and contracts equally in all directions  
15 during changes in temperature so that alignment is not  
16 affected and the module provides a constant output under  
17 varying conditions.

BRIEF DESCRIPTION OF THE DRAWINGS

The foregoing and further and more specific objects and advantages of the invention will become readily apparent to those skilled in the art from the following detailed description of a preferred embodiment thereof, taken in conjunction with the drawings in which:

FIG. 1 is an end view of an optoelectric module in accordance with the present invention; and

FIG. 2 is a sectional view of the optoelectric module as seen from the line 2-2 of FIG. 1.

## Detailed Description of the Drawings

Referring to FIGS. 1 and 2, an end view and sectional view, respectively, are illustrated of either an optical-to-electrical or electrical-to-optical (hereinafter referred to as optical/electrical) module 10 in accordance with the present invention. It will be understood by those skilled in the art that modules of the type discussed herein are generally include as pairs of channels, one of which receives electrical signals, converts the electrical signals to optical (light) beams by way of a laser or the like and introduces them into one end of an optical fiber, which then transmits the modulated optical beams to external apparatus. The second channel or module receives modulated optical beams from an optical fiber connected to the external apparatus, conveys the modulated optical beams to a photo diode or the like, which converts them to electrical signals. In the following description, the apparatus and methods can be used in either of the channels but, since the optical portions of the two channels are substantially similar, only one channel will be discussed with the understanding that the description applies equally to both channels.

1       Module 10 of FIGS. 1 and 2 includes a receptacle  
2 assembly 11 and an optoelectric package 12 aligned and  
3 affixed together, as will be disclosed in more detail below.  
4 Receptacle assembly 11 is designed to receive an optical  
5 fiber 14 in communication therewith, in a manner that will  
6 become clear presently. In the preferred embodiment,  
7 optical fiber 14 is a single mode fiber (the use of which is  
8 one of the major advantages of the present invention)  
9 including a glass core 15 and a cladding layer 16.  
10 Receptacle assembly 11 includes an elongated cylindrical  
11 ferrule 20 defining a fiber receiving opening 21 at one end  
12 and a mounting flange 22 at the opposite end.

13  
14       Ferrule 20 has a radially outward directed step 24  
15 formed in the outer periphery to operate as a stop for a  
16 resilient sleeve 25. Sleeve 25 has an inwardly directed  
17 flange formed adjacent one end so as to engage step 24 and  
18 prevent relative longitudinal movement between ferrule 20  
19 and sleeve 25. Sleeve 25 also includes radially outwardly  
20 directed ribs or protrusions 26 in the outer periphery that  
21 are designed to frictionally engage the inner periphery of a  
22 mounting housing 30. Thus, to easily and conveniently mount  
23 module 10 in housing 30, ferrule 20 with sleeve 25 engaged  
24 thereover is press-fit into the circular opening in housing  
25 30 and frictionally holds module 10 in place. Preferably,

1 sleeve 25 is formed, completely or partially, of some  
2 convenient resilient material and may be electrically  
3 conductive or non-conductive as required in the specific  
4 application.

5

6 Progressing from opening 21 toward flange 22, ferrule  
7 20 has two radially outwardly directed steps 32 and 33.  
8 Step 32 provides a surface or stop for the mounting of an  
9 optical spacer 35 and step 33 provides a surface or a stop  
10 for the positioning of an optical lens assembly 36. In this  
11 preferred embodiment, lens assembly 36 is formed of plastic  
12 and may be, for example, molded to simplify manufacturing of  
13 module 10. It should be understood that the term "plastic"  
14 is used herein as a generic term to describe any non-glass  
15 optical material that operates to transmit optical beams of  
16 interest therethrough and which can be conveniently formed  
17 into lenses and the like. For example, in most optical  
18 modules used at the present time the optical beams are  
19 generated by a laser that operates in the infra-red band and  
20 any materials that transmit this light, including some  
21 oxides and nitrides, come within this definition.

22

23 Lens assembly 36 defines a central opening for the  
24 transmission of light therethrough from one end to the  
25 opposite end along an optical axis Z. A lens 39 is

1 integrally formed in the central opening a fixed distance  
2 from optical spacer 35. Lens assembly 36 is formed with  
3 radially outwardly projecting ribs or protrusions in the  
4 outer periphery so that it can be press-fit into ferrule 20  
5 tightly against spacer 35. Thus, lens assembly 36 is  
6 frictionally held in place within ferrule 20 and holds  
7 spacer 35 fixedly in place. Also, lens 39 is spaced a fixed  
8 and known distance from spacer 35. In this preferred  
9 embodiment, optical fiber 14 is inserted into ferrule 20 so  
10 that glass core 15 butts against spacer 35, which  
11 substantially reduces or suppresses return reflections.  
12 Further, by forming spacer 35 of glass material with an  
13 index of refraction similar to the index of refraction of  
14 glass core 15, spreading of the light beam is substantially  
15 reduced and lower optical power is required to collimate the  
16 beam.

17  
18 Optoelectric package 12 includes a base or support  
19 plate 40 and a mounting plate 42 positioned thereon. One or  
20 more spacer rings 43 may be positioned on plate 42 to  
21 provide sufficient distance for components mounted thereon.  
22 In this example a laser 45 is mounted on the upper surface  
23 of mounting plate 42 and positioned to transmit light  
24 generated therein to a lens block 46. Alternatively, laser  
25 45 could be a photodiode or the like. Lens block 46 is

1 mounted on mounting plate 42 by some convenient means, such  
2 as outwardly extending ears (not shown). A ring 47 is  
3 positioned on spacer rings 43 and a cap or cover 48 is  
4 affixed to ring 47. Generally, the entire assembly,  
5 including plate 40, mounting plate 42, spacer rings 43, ring  
6 47 and cover 48 are fixedly attached together by some  
7 convenient means, such as welding, gluing, etc. so that  
8 laser 45 is enclosed in a hermetically sealed chamber.  
9 However, a hermetic seal is not necessary in many  
10 embodiments in which the laser or photodiode used is either  
11 separately sealed or is not sensitive to atmospheric  
12 conditions. Connections to the electrical components can  
13 be, for example, by coupling through plate 40.

14  
15 A window 50 is sealed in cover 48 so as to be aligned  
16 with lens block 46. Lens block 46 redirects light from  
17 laser 45 at a ninety degree angle out through window 50  
18 along optical axis Z and may include one or more lenses or  
19 optical surfaces. Further, as illustrated in FIG. 2, window  
20 50 is affixed to the underside of cover 48 by some  
21 convenient means, such as epoxy or other adhesive, so as to  
22 hermetically seal the light transmitting opening through  
23 cover 48. If a hermetic seal is not required, window 50 and  
24 any lenses incorporated therein can be formed (e.g. molded)

1 from plastic. In many applications, lens block 46 may be  
2 molded from plastic for convenience in manufacturing.

3  
4 Optoelectric package 12 is affixed to receptacle  
5 assembly 11 with flange 22 of ferrule 20 butting against the  
6 upper surface of cover 48. Further, optoelectric package 12  
7 is optically aligned with receptacle assembly 11 so that  
8 light from laser 45 is directed along optical axis Z into  
9 core 15 of optical fiber 14. This alignment can be  
10 accomplished in different ways but one reliable method is  
11 known as active alignment. In this process, laser 45 is  
12 activated and receptacle assembly 11 is positioned  
13 approximately over optoelectric package 12. The light in  
14 optical fiber 14 is measured and the alignment is adjusted  
15 for maximum light. When maximum light is measured alignment  
16 has been achieved and receptacle assembly 11 is fixed to  
17 optoelectric package 12 by some convenient means, such as  
18 welding or adhesive.

19  
20 Here it should be specifically noted that ferrule 20 is  
21 formed so as to be symmetrical about optical axis Z,  
22 referred to herein as "radially symmetrical". FIGS. 1 and 2  
23 illustrate the fact that module 10 is radially symmetric.  
24 Also, in this preferred embodiment a "two lens system" is  
25 used to communicate light between an optical fiber (14) and

1 an optoelectric device (e.g. laser 45). One of the lenses  
2 of the lens system is mounted in the receptacle assembly 11  
3 and the other lens is mounted in the optoelectric package  
4 12. It should be noted that the term "two lens system"  
5 refers to at least a first lens mounted a fixed distance  
6 from an optical fiber and at least a second lens mounted a  
7 fixed distance from an optoelectric device (e.g. laser 45).  
8 The "two lens system" substantially improves the tolerance  
9 of the distance between the two lenses along optical axis Z.  
10 For additional information on the "two lens system" refer to  
11 copending United States Patent Application entitled  
12 "Optoelectric Alignment Apparatus", filed in 12 September  
13 2001, with serial number 09/954,919, and incorporated herein  
14 by reference.

15  
16 The combination of the radially symmetrical  
17 construction and the "two lens system" substantially reduces  
18 the effects of temperature changes by expanding and  
19 contracting equally in all directions. Thus, during  
20 temperature changes optical axis Z and all components  
21 aligned along optical axis Z remain aligned. Further, the  
22 radially symmetric feature provides several advantages in  
23 construction and assembly, at least one advantage being that  
24 assembly into housing 30 does not require any kind of  
25 alignment.

1 In a preferred embodiment, ferrule 20 is formed of an  
2 electrically conductive material, such as any of the easily  
3 workable metals. Also, sleeve 25 is formed of any of the  
4 well known resilient plastic/metal combinations so that it  
5 is electrically conductive. Cover 48 of optoelectric  
6 package 12 is also formed of metal and receptacle assembly  
7 11 is affixed to optoelectric package 12 by a convenient  
8 welding process. Further, because module 10 is symmetric  
9 about optical axis Z, ferrule 20 can be easily frictionally  
10 engaged in housing 30 using resilient sleeve 25. In this  
11 fashion the entire module 10 can be assembled and mounted  
12 using well known machine assembly techniques.

13

14 Accordingly, a new and improved radially symmetrical  
15 module is disclosed which is easily assembled and mounted.  
16 Because a "two lens system" is used in conjunction with a  
17 radially symmetrical mounting structure, the distance along  
18 the optical axis between the pair of lenses is not critical.  
19 Also, the new and improved radially symmetrical module  
20 expands and contracts equally in all directions during  
21 changes in temperature so that alignment is not affected and  
22 the module provides a constant output under varying  
23 conditions and, thereby, improves the efficiency of the  
24 optical system. Also, manufacturing tolerances can be  
25 substantially reduced, greatly reducing manufacturing time,

1 labor, and costs. Further, the new and improved features  
2 allow the use of a variety of components and component  
3 materials (e.g. plastic lenses and other optical  
4 components).

5

6 Various changes and modifications to the embodiments  
7 herein chosen for purposes of illustration will readily  
8 occur to those skilled in the art. To the extent that such  
9 modifications and variations do not depart from the spirit  
10 of the invention, they are intended to be included within  
11 the scope thereof which is assessed only by a fair  
12 interpretation of the following claims.

13

14 Having fully described the invention in such clear and  
15 concise terms as to enable those skilled in the art to  
16 understand and practice the same, the invention claimed is: